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ADAPTATION OF INDUSTRIAL AND PUBLIC WORKS TECHNOLOGY TO THE CONDITIONS OF DEVELOPING COUNTRIES

Report of Activities

July 1, 1972 to September 1, 1973

under

Five Year 211D Grant, AID/CSD 3360

(December 1, 1971 to December 1, 1976)

SUMMARY

Period of Grant: December 1, 1971 to December 1, 1976
Amount of Grant: $900,000
Expenditures for Report Period (14 months): $213,400
Accumulated Expenditures: $225,300
Anticipated Expenditures for next Year: $230,000

The Technology Adaptation Program at MIT has been designed to strengthen the Institute's capacity to carry out research, analysis and training relating to the problems of adapting industrial and public works technology to the conditions of developing countries.

Investigations of various problem areas have been initiated by faculty and students in several departments of the Institute. In addition, several course offerings have been modified substantially in order to emphasize relevant problems of developing nations and one new interdisciplinary course has been developed specifically related to systems analysis and development.

The Technology Adaptation Program has made it possible for some members of the faculty in this subject area to have personal and direct involvement with international agencies, institutions in developing nations and individual investigators, working in related specialties and problems, both in the US and in developing countries,. As the content of the individual project reports illustrates, faculty and student participants have been deeply affected by their expanded personal and professional perception of the complexities of applying technology to developing nations.

Besides these sponsored activities, the Program has been effective in increasing the general awareness of the Institute faculty regarding the problems of adapting technology to the conditions of developing nations. As a direct consequence, additional program proposals relating to tech-

nology and economic development have been generated for consideration by potential sponsors.

PROGRAM OBJECTIVES

The long-term objective of the Technology Adaptation Program at MIT is to develop a broadly based body of expertise at the Institute concerned with the problems of exploiting public works and industrial technology in developing countries and to utilize this expertise to maintain a continuing program of investigation and training. In its proposal dated August, 1971, the Institute indicated that it would utilize grant funds for the following program elements: 1. Research; 2. Course and Curriculum Development; 3. Faculty Development; 4. Fellowships and Student Stipends; 5. Travel; 6. Workshops and Conferences; 7. Library and Resource Materials; and 8. Establishing linkages with LDC Institutions.

The projects described in the next section comprise the essence of the Institute's program under the AID grant. Each project has had its own emphasis, is directed by a different faculty member and devotes a different fraction of its resources to each of the program elements listed in the proposal. Some projects have emphasized curriculum development, others research, and still others faculty development but some general comments can be made about the overall distribution of the total program.

-Research, course and curriculum development, and faculty development represent the bulk of our effort to date.

-Essentially all library and resource material acquisition has utilized the Institute's general library funds and facilities. Individual projects have, of course, collected some highly specialized material relating to individual needs but it was decided that the program should not attempt to acquire a complete and centralized document collection since doing so

would be very costly diverting funds from other parts of the program.

-The Workshops and Conferences sponsored by the program to date have been internal to MIT although non-MIT specialists have made presentations.

-Student support has been provided in the form of research assistantships to carry out specific research and analysis tasks for a senior investigator or for thesis research.

-Most project and senior investigators in our program have developed informal linkages with LDC institutions and research groups. The Program's travel budget has facilitated this communication. After careful deliberation, we decided that formal institution-to-institution ties would not be particularly helpful in developing substantive working relationships because it would be difficult to find a single LDC institution which would serve the linkage needs across the broad spectrum of technical interests encompassed in our program.

PROGRAM MANAGEMENT

The faculty Steering Committee for the Program reports to the Provost and its membership is as follows: Peter Eagleson, Head of the Department of Civil Engineering; Everett Hagen, Professor of Economics and former Director of the Center for International Studies; William Pounds, Dean of the Sloan School of Management; Lloyd Rodwin, Head of the Department of Urban Studies and Planning; George Rathjens, Professor of Political Science; and J. P. Ruina, Professor of Electrical Engineering and Chairman of the Committee.

GENERAL BACKGROUND

Economic development generally requires an intensification of the exploitation of technology. However, the indus ., construction and

planning technologies useful for developed nations may not be adequate or even appropriate for the social, political, economic and environmental conditions in developing countries. Differences within countries must be taken into account in exploiting specific technology for optimal impact. High costs and risks and the unavailability of skilled, experienced professionals often make the development of brand new technologies not feasible. On the other hand, technologies available in developed nations may, in principle, be modified to provide a more suitable match to the needs of developing nations but this adaptation also presents problems.

A strong theoretical base does not exist to guide judgments regarding modifications of technologies of the developed nations for developing nations. Each case and each technological issue must be examined de novo. In some cases technologies can be transferred almost directly; in others the modifications or adaptation may be rather simple; in still others the problems of modification and adaptation may be substantial.

MIT's contributions as a research and educational institution have been concentrated on the frontiers of science and on the development of highly sophisticated technology. In the past, the Institute has also assisted in the establishment of educational institutions in LDC's, and individual faculty members have been involved in a wide range of public and private enterprises in developing nations. But the Institute's activities have primarily related to technologies for meeting the perceived needs of developed nations. The Technology Adaptation Program now aims to strengthen the Institute's capability for creative application of technology for the needs of developing nations. This objective is compatible with faculty and student interest in expanding the possibilities for applying technology to societal problems. In addition, the Institute educates many students from developing nations and, therefore, has a special incentive to devote a substantial fraction of its total efforts to the problems that are faced by their home countries.

PROJECT DESCRIPTIONS AND ACCOMPLISHMENTS

1.

Title: Application of Highway Cost Model to Venezuelan Road Transportation

Principal Investigator: Professor Fred Moavenzadeh, Civil Engineering

With the support of the Technology Adaptation Program, Professor Moavenzadeh and his colleagues continued their work on Highway Cost Modelling. Research activities focused on data collection and development and preparation of highway inventory systems. The purpose of this research was to test and validate stage construction capabilities of the model as a tool in planning highway links and in the scheduling of maintenance and reconstruction.

The model is designed to provide LDC's with a quantitative means to evaluate alternative road construction options and select those most suited to their overall needs, and to provide the international aid and lending agencies with a similar means for evaluating requests for grants and loans in road transport sectors.

The calibration of the model was carried out through cooperative work with the appropriate agencies in Venezuela, Brazil and Colombia. During a trip to the above countries (plus Argentina) strong working relationships were established with the following agencies:

Venezuela: Consejo National de Vialidad (CONAVIAL), Univesterio de Obras Publicas

Brazil: P.U.C. - Pontifica Universidade Catolica.

Dr. Hani Findakly, a research associate at MIT whose work under Professor Moavenzadeh was partially supported by this project, is currently on an OAS Fellowship as a Visiting Professor at P.U.C. working on the application of the Highway Cost Model to Brazilian Highway Construction Program. The project also supported in part the work of four

undergraduate and one graduate students who were working directly on the Venezuelan model.

Professor Moavenzadeh's course on "Highway Technology" was substantially modified by his research, with material developed in Venezuela and Brazil being directly incorporated into the subject matter of this course. In addition, a large proportion of a newly developed course entitled "Macro-Construction Engineering" will be related to the research project of Professor Moavenzadeh.

During the project year, Professor Moavenzadeh also presented two papers which were connected to his work on Highway Cost Model:

-Transfer and Adaptation of Technology in the Construction Industry, presented at the A.I.D. Symposium on Bilateral Aid Strategies and Programs in Selected Areas of Science and Technology, Cornell University, May 7-8, 1973.

-Selection of Optimal Investment Strategies for Low Volume Roads, to be presented at the annual meeting of the Planning, Transport, Research and Computation Company Ltd., University of Sussex, June 1973.

Copies of these two papers are appended.

2.

Title: Water Resources Technology Adaptation

Principal Investigators: Professors Frank E. Perkins and David C. Major, Civil Engineering

Modern water resources planning technology can be characterized by an integrated use of:

i) The complete set of optimal public expenditure criteria.

ii) Mathematical modelling techniques that relate investment criteria and the water resource system.

Although the technology defined by these two components has been applied in a reasonably complete form in only a few cases, there is evidence that it will become a standard basis for federal planning in the United States and will have an influence on the criteria used by international funding agencies.

In contrast to this more modern planning technology are the procedures typically in effect in less developed countries and still to some extent in developed nations. These latter procedures include planning single projects for single purposes; using investment criteria which are almost exclusively market oriented, neglecting of basin or regional considerations, and maintaining little relation among individual projects and overall national goals. While in some instances, mathematical models have been employed, these have usually been as direct substitutes for existing procedures rather than as part of a fundamental change in the planning process.

The objective of this project is to investigate the extent to which modern water resource planning technology is applicable to the planning process in less developed countries, and to assess the potential benefits which might derive from application of this technology.

As a prelude to visiting water resource planners in several Asian and African nations the investigators engaged in extensive discussions with

personnel in U.S. and international agencies located in the U.S. The objective in these discussions was to assess the level of planning expertise and to determine the probable acceptability for establishment of an ongoing research project in various countries. The agencies with which these discussions were conducted include U.S. AID, UNDP, UN Resources and Transport Division, and the World Bank.

Professors Perkins and Major visited with water resource planners in Asian countries selected on the basis of agency discussion. Professor Major visited African countries in March. Both trips were for the following purposes:

i. to learn about the sources and reliability of hydrologic, economic, and other water resources project planning data;

ii. to examine specific project planning documents;

iii. to discuss planning standards and criteria with local planning authorities and with local AID, World Bank and other mission personnel;

iv. to assess the personnel and computational resources available for water resource planning, both in the government and in the universities.

As a result of these activities, Korea was identified as the country with the greatest potential for future projects. A feasibility study was carried out on collection and evaluation of data for the Han River, an examination of river basin planning models, and a definition of the planning and operational decisions which are at issue on the Han River. This preliminary work has fostered working relations between the investigators and the Korean Bureau of Water Resources (Ministry of Construction) as well as the Korea Water Resources Development, the Economic Planning Board and the Korea Institute of Science and Technology (KIST).

In the area of research the investigators have tentatively advanced the concept of the production function to planning for water resource development. The production function concept appears to be a useful

framework for considering the value of technology adaptation and will, subject to appropriate funding, be expanded on in future research.

The project has had a professional and personal impact on Professors Perkins and Major and this has already been reflected in their teaching. This is especially true in the undergraduate subject, 1.60--Introduction to Water Resources and the graduate subjects, 1.74--Public Expenditure Theory, and 1.732--Water Resource Systems. In all of these there was ample opportunity to incorporate both the general issues and case study details from material gathered during our country visits. In addition, Professors Major and Perkins have become considerably more sensitive to the complexities of technology transfer and the necessity for careful assessment of each case.

Professor Perkins presented a summary of observations concerning water resource planning Asia to the weekly Water Resources Division Seminar of the Civil Engineering Department at MIT.

In November, Professor Major presented a paper entitled "Notes on the Program in Technology Adaptation at MIT" at the Batelle Research Conference on Successes and Failures in Technology Transfer in Seattle, Washington. A second paper on "Investment Criteria and Mathematical Modelling Techniques for Water Resources Planning in Argentina: the MIT Argentina Project" was presented by Professor Major at the IFAC /IFORS Conference on Systems Approaches to Developing Countries, in Algeria, May 1973. These two papers are appended together with an outline of a summary and evaluation of a number of planning studies in less developed countries and several research studies in which the role of mathematical models were applied.

3.

Title: Urban Transportation in Developing Countries

Principal Investigators: Professors Nigel Wilson and Daniel Roos, Civil Engineering

The objectives of this study are to learn about factors which influence urban transportation planning and investment in large Latin American cities. Many of these cities are now in the process of making major and far-reaching decisions about their future urban transportation systems. Capital intensive public systems such as rail rapid transit are being implemented or planned in many of these cities. At the same time automobile ownership is growing rapidly and development of networks of urban expressways are also being planned. In this environment of heavy investment with decisions being made which will affect the structure of the cities as well as the transportation system, it is important that planning techniques and transportation systems should be designed for the economic and social conditions in the area, rather than lifted from the U.S. as Western European context.

This project is intended to explore the transportation system and planning techniques appropriate for major Latin American cities. During the first year of the study a thorough understanding of the range of systems now available and being contemplated, the institutional regulatory and economic frameworks for these systems, and the transport needs has been obtained. Now attention is being directed to analysis of feasible transportation alternatives to identify the incidence of costs and benefits in different situations. Results of these analyses will be a comparison of the available systems in a range of situations and conclusions about the benefits of possible alternative pricing regulatory and institutional frameworks under which these systems could be implemented.

The insight gained into urban transportation in Latin America has been used to develop new educational material in several courses. A

new course on Transportation Policy (1.262J) is oriented to a comparison of governmental roles in the U.S. and abroad, and this study has contributed directly to about 25% of the course material. An existing course "Innovative Urban Transportation" (1.25) now includes material on systems in existence and under consideration for Latin American cities; this study has contributed about 10% of the material in this course. An existing course on Modelling Transportation Systems (1.203) now includes about 15% material on comparison of urban transportation systems developed under this study.

There are two main directions the research is currently taking. First models are being developed which describe the operation of alternative urban transportation modes. Those models are general in that inputs are in the form of resources and outputs are in the form of travel volumes and level of service parameters. With data already obtained and other data currently being requested from various Latin American cities on factor prices and travel demand these models are being used to compare the transportation systems on the basis of total cost and user benefits. The aim of this research is to have a model system which can be used to determine the most efficient mix of transport services in a given environment.

The second main research thrust is to identify and measure the incidence and amount of benefits associated with a major urban transportation investment. This effort is aimed at identifying an appropriate level of urban transport investment for a developing country in view of the benefits derived, and also to define equitable and feasible financing and pricing strategies to ensure that the project can be implemented. In the course of this work financing and pricing policies proposed and implemented elsewhere will be evaluated. An important output of this analysis will be a review of the institutional and regulatory framework necessary for efficient urban transportation services.

One draft report has been completed entitled:

"Comparison of Urban Transportation Modes in a Developing Country Context" by Alan M. Castaline, Department of Civil Engineering, May 1973.

During the course of the first year visits have been made to Caracas, Bogota, Sao Paulo and Rio de Janeiro and close working relationships have been developed with the following groups in these cities:

Caracas:	Oficina Ministerial de Transporte, Metro de Caracas
	Direccion de Planeaniento Urbano, Ministry of Public Works
	Planning Department of the Distrito Federal
	Comision del Desarollo Urbano del Pais
	Consejo Nacional de Vialidad
Bogota:	Universidad de Los Andes
	Oficina de Planeacion Socio-Economica, Distito Especial
	Planeacion Nacional
Sao Paulo:	Economic and Planning Department, State of Sao Paulo
	Companhia do Metropolitano de Sao Paulo
Rio de Janeiro:	Grupo de Estados para Integracao da Politica de Transportes

4.

Title: Air Transportation in Developing Countries

Principal Investigator: Professor Robert W. Simpson, Director, Flight Transportation Laboratory, Aeronautics and Astronautics

A sound transportation infrastructure is essential to the economic development of a nation. When the volume to be transported is light, both in cargo and passengers, transportation by air is often the most efficient mode. This may be particularly true in developing nations. Thus the first objective of the project was to educate personnel at the Flight Transportation Laboratory about the nature of the problems faced by developing countries in the air transportation area.

As a result of investigations undertaken in the pursuit of this objective and visit to organizations active in international aviation, the Flight Transportation Laboratory determined that the most immediate way it could help developing nations would be to organize an Advanced Study Program in Air Transportation at the MIT Center for Advanced Engineering Study.

The program is designed for individuals who have supplied and will continue to supply the initiative, leadership and accomplishment that has catalyzed progress in the development of the world's air transportation systems: practicing professionals drawn from airport operators, airline managements, government agencies, and aviation manufacturers. It is a multidisciplinary program covering technology, management, economics, law, and operations research, designed to prepare the participant for a career in managing and planning the development of air transport systems.

To insure that the program is relevant to developing countries other than the United States, invitations were sent to Directors General of Civil Aviation to attend a short seminar at MIT during the course of their attendance at the Conference on the Economics of Route Air Navigation Facilities and Airports (ERFA) which was convened by ICAO in Montreal during the

month of February, 1973. The intent of the seminar was to solicit the opinions of these informed professionals, both as to the content and the duration of the study program. The response was favorable. Some 30% of the nations attending the conference participated in the seminar. Particularly helpful to orient the program at the seminar were comments from the delegates of Brazil, Nigeria, and Trinidad and Tobago.

As a result of the visits made, personnel from the Flight Transportation Laboratory have established a close working relationship with the Bureau of Technical Assistance, International Civil Aviation Organization. These contacts have led to the participation in the Advanced Study Program of a member of the faculty of the ICAO Civil Aviation Safety Centre in Beirut.

The work undertaken under this project will be useful for curriculum development of a course on air transportation problems in developing countries. The research undertaken to date has resulted in the publication of a MIT working paper, FTL Technical Memorandum 73-12, Air Transportation in Developing Countries, which is appended.

5.

Title: Systems Analysis as an Aid in the Development Process

Principal Investigator: Professor Robert E. Stickney, Mechanical Engineering

As systems analysis is a widely used, valuable technique in the developed countries and one which has been much used and refined at MIT, its application to the problems of developing countries is a logical step. The objectives of this project were first, to provide a detailed test of the usefulness and limitations of systems analysis as an aid to developing countries in their planning and evaluation of alternative development programs, and second, to prepare several case studies illustrating the application of systems analysis to development problems.

The initial test selected for the project was the development of a systematic method for evaluating alternative nutrition programs for a developing country. An attempt was made to develop a detailed model of the principal factors influencing the nutritional and health status of young children (0 to 3 years of age) of low income families in developing countries. In addition, work was done on problems relating to nutrition planning in El Salvador such as: formulation of simple analyses to help the nutrition planning group design and evaluate low-cost food supplementation programs (including some nutrition education and medical care) for young children and pregnant women, and a qualitative examination of a systems approach to the evaluation of various alternative nutrition-related programs now being considered by the government of El Salvador.

As a result of their research, Professor Stickney and his colleagues have established a close working relation with various members of the Institute of Nutrition of Central America and Panama (INCAP). Professor Stickney is currently working with Applied Nutrition Division of

INCAP in Guatemala, where he will stay for nine months.

The grant enabled Professor Stickney and a Research Assistant to travel to Mexico City in September, 1972, to attend the 9th International Congress on Nutrition, where they presented a paper summarizing preliminary work on the application of systems analysis to nutrition planning. One of the objectives of the trip was to establish communication with nutrition groups in developing countries and to identify systems projects that would be of value to their work.

The grant also supported travel for Professor Stickeny to Europe and Algeria in late May and early June of 1973. The purposes of this trip were: (1) Visit FAO in Rome to discuss nutrition systems analysis problems with members of their Nutrition Division; (2) Attend the IFAC-IFORS International Conference on Systems Approaches to Developing Countries (Algiers, May 28-31) and to present a paper summarizing work on nutrition systems analysis; (3) Visit UNICEF in Algiers and Geneva to learn of the nutrition programs in North Africa based on the production of high-protein foods; (4) Visit WHO in Geneva to discuss the use of systems analysis in the planning of health and nutrition programs in developing countries. In addition Professor Stickney visited Chile and El Salvador as a member of the MIT Nutrition Planning Group (expenses were covered from sources other than the 211d grant).

In the spring term of 1973 Professor Stickney offered a new subject, "Modeling and Analysis of Systems Pertaining to National Development." This was a graduate-level, interdepartmental subject offered jointly by the departments of Mechanical Engineering, Civil Engineering (Professor R. de Neufville), and Nutrition and Food Science (Professor N. S. Scrimshaw). The principal objective was to introduce students to the systems approaches and techniques that may be useful in studies of problems relating to national development. The major emphasis was on case studies and homework problems illustrating the advantages, as well as the limitations, of systems analysis. The topics covered included

production functions, marginal analysis, linear programming, sensitivity analysis, estimation of input values, evaluation of projects, net present value, simulation models, utility functions, decision analysis, welfare economics, and econometrics.

Twenty-five students from a wide variety of fields enrolled in the subject. Approximately half of them were from developing countries. Near the end of the term, each student wrote a hypothetic proposal to a government planning agency describing in detail how systems analysis could be applied to a specific problem of national development. The students were allowed to select a problem of personal interest to them, and the problems they selected were in various areas (e.g., transportation, energy and power, agriculture, mineral resources, education, medical care, and nutrition).

The work conducted by Professor Stickney and his associates resulted in a paper presented in a symposium in Algeria and published under the title, "Systems Approach to Nutrition Planning: Preliminary Considerations" in Proceeding of the Symposium on Systems Approaches to Developing Countries. This paper and the abstracts of four master's theses are appended.

6.

Title:	Materials Adaptation for Developing Nations
Principal Investigators:	Professors N. Cook and P. Griffith, Mechanical Engineering

The objective of the project was to explore and evaluate the possibility of using a cement based substitute for conventional metals. Ferro-cement was chosen as a possible substitute material candidate in two areas:

(1) In the construction of machine parts (such as pump housings, machine frames, etc.) and

(2) In the construction of heat exchanger shells.

The grant supported, and Professor Cook supervised, the work of four undergraduate students in the area of construction of machine parts. The work of two students was focused on an analysis of ferro-cement properties such as

i. Optimum mortar strength characteristics

ii. Qualitative mesh analysis tests

iii. Ultimate bending moment tests

iv. Deflection due to bending tests.

Another student worked on the application of ferro-cement in bearings. All three students prepared reports on these subjects (see Appendices). A fourth student completed a bachelor's thesis (B.Sc.) on the subject of "A Study on Ferro-Cement: Theories, Properties and Applications" (the abstract has been appended).

In the area of heat exchanger shells, the work was carried out again by four students under the supervision of Professor Griffith. The result of their research is included in three reports and one Bachelor's thesis on the following subjects:

i. An Estimate of Steam Condenser Needs for ldc's

ii. A Reinforced Concrete Shell for the Conventional Single-pass, Single or Multi-pressure Steam Condensers (including a Concrete Steam Condenser Shell Construction Manual)

iii. Concrete Shell Heat Exchanger Protective Coatings

iv. The Air Permeability of a Commercial Concrete Pipe (B.Sc. Thesis).

Copies of the above reports and the abstract of the thesis have been appended.

In addition to the research carried out, Professor Cook and Professor Griffith have tried to identify potential users and/or developers of the ferro-cement materials system through their contacts in LDC's and international organizations.

7.

Title:	The Transfer and Adaptation of Housing Technology and Standards to the Needs of Developing Countries
Principal Investigator:	Professor Ian Donald Terner, Urban Studies and Planning

The goals of this project were fourfold: (1) Analyze the simple, locally-inspired ways in which developing nations might use indigenous materials and capabilities, supported by new technology, to increase the safety, speed, and ease of self-help building methods; (2) Document the failures of industrialized housing technology transfers from developed to less developed nations and help to formulate policy guidelines to prevent the repetition of such failures in the future; (3) Document the impact of new technologies, as less developed nations attempt to use them in construction sector modernization programs; and (4) Create several documented case studies and other teaching materials that can be packaged for short-term training institutes to be held at MIT or at various locations throughout the world. Such training institutes will help to promulgate various strategies designed to enhance the transfer and adaptation of housing technology and standards to the needs of developing countries.

AID funds, supplemented by money from other sources, have supported the research activities of eight graduate students (five from developing nations and three from the U.S.), under the direction of Professor Terner, in the following areas:

- -The relationship between housing policy and technology in Korea (thesis)
- -The relationship between housing policy and technology in East Africa
- -The political implications of foreign assistance in the area of imported/transferred housing technology (thesis)

- The special aspects and requirements of emergency and disaster housing technologies
- Compatibilities and misfits between housing technology and aspects of environment and life style
- The coordination of housing components and the feasibility of self-sufficient building kits
- Case studies of the impact of industrialized building technology in developing areas
- The industrialization of the site: new technology applied to site preparation and infrastructure.

One of the new links between the research program and Third World Nations and international institutions has been through the provision of a draft textbook and reference set on housing policy and technology in developing areas. This has been distributed to MIT students and international institutions (including the Asian Institute of Technology, Bangkok, Thailan University of Nairobi, Kenya; Department of Architecture, School of Planning, Ahmedabad, India; Universidad Ibera-Americana, Mexico City, Mexico). The distribution of the textbook was for trial use, feedback and revision. In addition, the project has also undertaken field work in East Africa and Mexico, and has established contact with the U.N., World Bank, Interamerican Development Bank, and the National Academy of Sciences Office of the Foreign Secretary.

The project investigators have been invited to several national and international conferences and meetings including:

- The First International Congress on Technology Assessment, The Hague, Netherlands, May-June 1973 where a paper was presented.
- MIT Summer Session on Building Technology, Guest Lecture, August 1973.
- Seminar on Housing Technology, Sir George Williams University, Montreal, Canada, September 1973.
- Evening Seminar Series on Housing and Urban Problems, Boston University, Guest Lecture, September 1973.

Two courses (11.421 and 11.422 Self-Help Housing, Squatters and Social Change) have been revised to further develop and disseminate the research findings, and to place the research in an overall policy context. Particular emphasis is placed in the courses on:

*Technology assessment, adaptation, and transfer procedures;

*The relationships between housing technology and housing policy;

*The physical, economic, social and political impacts of new or adapted housing technology on the quantity, quality, and distribution of housing and housing services, and on the related aspects of employment, income distribution, migration and balance of payments; and

*The special demands and requirements placed on housing technology by the extreme circumstances of emergency or disaster such as flood, war, earthquake, etc., and the special opportunities afforded to technological solutions during such periods.

8.

Title: Development of Basic Performance Standard for Urbanization and Housing Technologies through Testing of Models in Nairobi, Kenya

Principal Investigators: Professor Horacio Caminos and Mr. Reinhard Goethert, Architecture

The objective of the project was to develop basic performance standards for urbanization and housing technologies, including environmental conditions, physical characteristics, utility networks, service facilities, regulations, circulation systems, housing systems and land development opportunities.

Housing standards in developing countries are generally more appropriate to the conditions of advanced nations. Revision of these standards, to allow a transfer of housing technology compatible with local materials, techniques and cultures, is badly needed.

During the summer of 1972, a group of MIT faculty and graduate students went to Nairobi, Kenya to evaluate local housing systems, future housing needs and performance requirements. The medium of the work was field studies, workshops and seminars in collaboration with the University of Nairobi and the Nairobi City Council. Tentative performance standards were formulated and compared with United States and Latin American references. Finally models were prepared during the 1972-73 academic year for testing of standards. In particular the project activities, in which 16 graduate students participated, involved the following:

Intensive field work was carried out during the summer in Nairobi, Kenya. The emphasis was on testing, updating, and further development of materials and studies initiated at MIT.

A two day workshop addressed to housing issues in developing countries was jointly sponsored with the University of Nairobi in Nairobi, Kenya. Approximately 50-90 persons attended by invitation only, includ-

ing a six member delegation television coverage reported a favorable reception.

Extensive filming of various urbanization issues were carried out during the two month summer period in Nairobi, with the assistance of the MIT Film Section Professor Kaj Anderson, University of Nairobi. Parallel film documentation was undertaken in Mexico City for eventual editing and combination with the work in Nairobi.

Summer collaborative work with the University of Nairobi in which seminars, informal class presentations and critical discussions were offered to faculty and students on the following themes: 1) Buildings and Urban Environments; the process of development; design, construction, utilization and evaluation. 2) Educational Buildings for Venezuela; primary and secondary schools, standards and prototypes, site development design, construction. 3) University Campus Buenos Aires, Argentina; site development, design, construction. 4) University Campus Los Andes, Venezuela; site development, design, construction. 5) Two reinforced concrete construction systems for self-help housing.

Many other agencies, institutions, and individuals were contacted during the summer in Nairobi in order to receive as many viewpoints in regard to housing standards, low income people, and developing countries. The agencies contacted included: Nairobi City Council: Town Clerk's Department, City Engineer's Department, Urban Study Group, Planning Section, Architecture Section; University of Nairobi: Housing Research and Development Unit, Design Research and Development Unit.

A study trip was taken in Tika, Kenya, an industrial town being developed 50 km. northeast of Nairobi. The town illustrates long range planning and different types of low cost housing including a proposed AID funded project. Field trips were also taken to Kampala, Uganda and Dar Es Salaam, Tanzania, to observe other East African housing contexts.

The activities of the members participating in this project have strengthened two related graduate courses:

4.160 Urban Settlement Design in Developing Countries

4.161 Urban Settlement Design in Developing Countries

This course sequence has been engaged in urbanization problems since 1965. The course is based on (1) field work by faculties, research staff and students, (2) analytical and case studies based on data and insights gathered in the field; (3) dissemination through interchange in polyglot graduate student groups whose members return to apply the technologies in their own countries.

Until last year, the work had been based primarily on experience in Latin America: Colombia, Peru, Argentina, Puerto Rico, etc.

In brief, the course sequence has been strengthened by: (a) experience in a new context, East Africa; (b) gathering of considerable amount of new data: case studies, reports, surveys, models; (c) participation of all members of the class (16), including the group that went to Kenya through analysis and design of housing projects; (d) thesis work on housing/urbanization problems in Kenya.

In addition, the following publications have resulted from the support of the grant:

IDENTIFICATION OF DWELLING SYSTEMS IN NAIROBI, KENYA (Urban Settlement Design Program). Twenty case studies of typical dwellings have been surveyed and analyzed. The major areas covered include the following:

Users: origin, educational level, family pattern, migration pattern, income group, employment, etc.

Dwelling/lot/land: location, type, area, tenure, utilization, year of construction, mode of development, builder, construction type, materials, facilities

Community: facilities, utilities, services.

The work will be particularly useful for the formulation of housing policies, programs and standards.

"INTERIM URBANIZATION PROJECT DANDORA: A Progressive Development Proposal including a SITE SERVICES model" (Urban Settlement Design Program; Spring 1973, 46 pages). The publication describes an

urbanization model for 60,000 to 120,000 people in Nairobi, Kenya. The project was prepared at the invitation of the Nairobi City Council.

BASIC PERFORMANCE STANDARDS FOR URBANIZATION IN LATIN AMERICA AND EAST AFRICA (Urban Settlement Design Program). Three major areas, site selection, evaluation and planning, were covered with emphasis on the following: location, approaches, accesses, transportation, size, shape, land costs, land ownership, boundaries, natural features, soil, climate, existing facilities, government bylaws, etc.

RESIDENTIAL LAND UTILIZATION: CASE STUDY NAIROBI, KENYA, Urbanization in Developing Countries Series (Thesis; M. Arch. A.S., George Gattoni and Praful Patel authors, 1973). Twelve selected localities of the Nairobi Metropolitan Area are surveyed, evaluated and compared. The localities represent the full range of residential developments of the popular, public and private sectors. The thesis provides a reference and a set of guidelines for land use and density for future residential developments in Nairobi.

9.

Title: Organizational Studies and Development

Principal Investigators: Professor George Farris and Dr. Anthony Butterfield, Sloan School of Management

The objective of this project was to design a long-range program leading to the institutionalization of organizational research and development capabilities within Brazil.

The investigation undertook a fact-finding mission to Brazil to attend a meeting of key parties who would be potentially involved in the creation of a Brazilian Center for Organization Management Technology. During this visit they also held discussions with appropriate agencies regarding the Sao Paulo Technology Utilization Program, a program designed to upgrade the state of technology and increase its utilization by Sao Paulo industry. Several other projects were also investigated.

As a result of the contacts made by Professor Farris, a Brazilian group headed by Dr. Jose Pastore visited MIT in May 1973 to explore further the possibility of collaborative programs with MIT.

Professor Farris made use of the exposure he got on the problems of organizational studies in Brazil in his course on "Comparative Organization" (Course 15.317). As a result of this visit to Brazil, Dr. Tony Butterfield was able to inject new material in the Latin America Section of the course on "International Business Environments" (15.223).

The investigators are in the stage of completing a paper on technology transfer from the point of view of social influence at three levels: the individual, the organization, and society. They have relied to a large extent on material collected with the support of this project.

10.

Title:	The Nature of R & D by Industrial Firms in India (Research for a Doctoral Thesis)
Principal Investigator:	Mr. Bruce Kutnick (Graduate Student, Sloan School of Management, under supervision of Professor J. Bhagwati)

Mr. Bruce Kutnick spent approximately eight months in India studying the extent, the scope, and the underlying motivating forces of industrial research and development in India. He used multi-variable regression analysis to identify variables such as: minimum firm size, annual profits, internal funds, investment behavior, import and export performance, and managerial attitudes, that influence the decision to initiate and carry on research. Some other questions investigated were the following: Within the firm how are R & D decisions made and by what criteria are funds allocated to projects? How effective has the investment in research been? With regards to R & D, how has private business responded to the direct and indirect incentives established by the government? Have research efforts made Indian products more competitive in world markets? Do multinational corporations follow a different type of research strategy than indigenous Indian firms? To what extent is securing foreign technology a substitute for or a complement to domestic R & D?

In the course of his research Mr. Kutnick interviewed more than 80 firms, industrial associations, research centers, and government agencies and ministries. Investigation of the general state of industrial R & D in India as well as a more detailed study of the pharmaceutical and dyestuff industries were undertaken.

During his stay in India Mr. Kutnick was affiliated with the Indian Statistical Institute in New Delhi. In addition, an informal working arrangement developed between himself and several people from the Council

of Scientific and Industrial Research who were engaged in a similar project.

Although this project is supported by the Technology Adaptation Program, the actual funding of Mr. Kutnick's trip to India was provided from other sources.

Mr. Kutnick's thesis is currently in the final stages of preparation and will be made available upon completion.

11.

Title: Electromagnetic Prospecting for Subsurface Water in Arid Regions

Principal Investigators: Professor G. Simmons, Earth and Planetary Sciences; Professor John V. Harrington, Electrical Engineering

This is one of three projects initiated in June 1973. Its objective is to develop a new electromagnetic prospecting technique for subsurface water for use in arid regions. An immediate urgency in this project stems from the severe drought conditions in West Africa coupled with the likelihood that the use of this technique will improve significantly the probability of drilling successful water wells.

In June 1973, field tests were conducted near El Paso, Texas with laboratory equipment. The site was chosen because of its arid climate, ease of logistics, excellent understanding of subsurface hydrology, availability of previous geophysical data, well-control of depths of water, and the broad range of depths to the water table (5-100 meters). The simultation of conditions (both surface and subsurface) in Mali and Senegal is excellent. Thus the first El Paso tests were intended to demonstrate validity of the theoretical concepts and to debuy "pre-prototype" field equipment. The results are currently being evaluated.

12.

Title: The Leadership Roles and Potential of Business Managers in Economic Development and Transfer of Technology in LDC's of Africa

Principal Investigator: Professor Willard R. Johnson, Political Science

This is the second of three projects initiated in June 1973. The project will document and analyze the real life experience of business managers in certain African countries in promoting general political and economic development and the transfer of industrial technology to the host environment. The project builds on work already started, and may complement work that could be supported from other sources. The project has already begun to develop collaborative relationships with relevant East African professionals, business leaders, training institutions and government agencies. These relationships will be broadened. The project will also investigate the need and potential for undertaking a long range project focused on developing and local management skills needed to permit a particular African country to transfer management control of highly sophisticated industrial technology to its own nations.

13.

Title:	Technology Adaptation in the Textile Industries of LDC's
Principal Investigators:	Professor Stanley Backer and Dr. Stelios Arghyros; Mechanical Engineering, Fibers and Polymers Division

This is the third project initiated in June 1973.

The Fibers and Polymers Division has provided Institute students with courses dealing with fundaments of textile science and engineering, particularly in the area of materials properties, textile processes and their interaction. In addition, undergraduate and graduate students, in collaboration with faculty members, have been involved in basic and applied research projects that bring them in contact with the most recent developments in the field of textiles.

The emphasis, however, has been on the technical problems of the textile industry in the U.S. The objective of the project is to strengthen the curriculum in the textile area by developing case studies, and technical and economic information specific to the problems of the textile industries of LDC's. The material developed during the year will become a permanent part of the curriculum in six courses offered by the Mechanical Engineering Department. In addition, it is hoped that the project will generate student interest for research projects on technical problems relevant to the LDC's.

LIST OF FACULTY PARTICIPANTS

Stanley Backer, Professor of Mechanical Engineering
Horacio Caminos, Professor of Architecture
Nathan Cook, Professor of Mechanical Engineering
Peter Eagleson, Professor of Civil Engineering
George Farris, Associate Professor of Management
Peter Griffith, Professor of Mechanical Engineering
Everett Hagen, Professor of Economics
John V. Harrington, Professor of Electrical Engineering
Willard Johnson, Associate Professor of Political Science
David C. Major, Associate Professor of Civil Engineering
Fred Moavenzadeh, Professor of Civil Engineering
Frank E. Perkins, Associate Professor of Civil Engineering
William Pounds, Professor of Management
George W. Rathjens, Professor of Political Science
Lloyd Rodwin, Professor of Urban Studies and Planning
Daniel Roos, Associate Professor of Civil Engineering
Jack P. Ruina, Professor of Electrical Engineering
Gene Simmons, Professor of Earth and Planetary Sciences
Robert W. Simpson, Professor of Aeronautics and Astronautics
Robert E. Stickney, Professor of Mechanical Engineering
Ian Donald Terner, Assistant Professor of Urban Studies and Planning
Nigel Wilson, Assistant Professor of Civil Engineering

SUMMARY OF NEW AND REVISED COURSES

1. New course derived from 211d Grant

   2.190J Modelling and Analysis of Systems Pertaining to National Development

   An exploratory introduction to the application of the concepts and techniques of systems analysis to problems pertaining to regional and national development (e.g. nutrition and population, transportation and communication, energy and power, utilization and conservation of natural resources) of both "developing countries" and "developed countries". Considerations of the utility and potential, as well as of the limitations and restrictions, of the approach as an aid in planning studies involving evaluation of alternative programs, strategies, and systems. Emphasis on: Modelling of the technical and behavioral features of a system by employing production functions and causal modelling; search for optimal system designs by use of marginal analysis, mathematical programming, and sensitivity analysis; and evaluation of projects with respect to time, risk and uncertainty, and the preferences of different target groups. Concepts and techniques illustrated through case studies and applied in term projects.

2. Courses in which a substantial amount of new material has been injected as a result of 211d Grant

   1.262J Transportation Policy Analysis

   Transportation policy at the national, regional, state, and local levels. Role of the U.S. Department of Transportation, the Interstate Highway Program and Urban Mass Transit Assistance Acts. Mechanisms of achieving policy implementation, comparison of U.S. transportation policy with policies in other countries. Principle policy making actors and interest groups at the metropolitan level, local funding sources.

1.25 Innovative Urban Transportation Systems

Investigation of the technical and institutional issues in urban transportation innovation. The ability of innovative urban transportation systems to meet present and future needs. The roles of government, private industry, labor and the transit industry in urban transportation innovation. Case study analysis of several new innovative systems including Dial-A-Bus, Personal Rapid Transit, and Dual Mode.

1.203 Transportation Supply Models

Basic characteristics of transportation technologies. Determination of capacity for highways, air transport systems and terminals, railroads, ports and terminals. Analysis of network operations. Transfer and classification systems. Cost and performance models and generalized parametric analysis. Problems in system unreliability. Use of descriptive and prescriptive modeling techniques to analyze and design transport systems with stress on operating policies to be used.

1.60 Introduction to Water Resources

Engineering, economic and political aspects of water resources management. Designed as a multi-disciplinary introduction to the field for those who wish to consider further work in water resources and for students in engineering, economics, political science, and management who wish to use water resources as a case study of an important resource sector largely affected by government management. Topics include: pollution, ecological aspects of water development, water management institutions, engineering economic design of water systems, formulation of objectives and criteria for water resource development, the role of the U.S. Congress and Federal agencies, water reuse systems, and global water problems.

1.74 Public Expenditure Theory

Presentation of the full range of benefit-cost criteria required for the optimal economic design of public expenditure projects. Emphasis upon water resource systems as specific examples. Provides necessary background in welfare economics and relevant material from political science dealing with the choice of objectives for public expenditure. Federal benefit-cost practices described and analyzed. Relates computer and mathematical programming techniques to public expenditure analysis.

1.732 Water Resource Systems

Flood forecasting, flood routing, flood plain management, flood control. River basin simulation. Synthesis of hydrologic inputs. Interactive use of simulation and mathematical programming models. Evaluation of long term net benefit and short run loss functions.

1.45 Highway Technology

Application of problem solving techniques to highway technology--design, construction, maintenance--with emphasis upon structural design. Systematic investigation of impact of overall transportation goals on highway performance evaluation, and user based approaches to this evaluation in terms of serviceability, reliability, and maintainability. Functional requirements of physical facilities as derived from performance evaluation. Formulation of alternative design actions and selection with economic and service quality criteria. Problems of construction and maintenance. Observation of actions as feedback to problem solving. Synthesis into overall framework for decision making.

4.160

4.161 Urban Settlement Design in Developing Countries

Advanced projects on Urban Settlement Environments for low income groups in developing countries. Aims: to prepare designers

to participate effectively in the process of shaping the environment; to develop tools to define and evaluate design determinants, and to make these tools available to those concerned and responsible for action at the policy making level.

11.421 Self-help Housing, Squatters and Social Change

Lectures and readings or research on the issues of autonomy vs. centralized authority in housing and the problems of the urban accommodation of low-income sectors undergoing rapid geographic, social and economic change. Case material from Africa, Asia, Latin America and the USA used in order to develop a methodology for the analysis of housing systems and as a comparative basis for the discussion of general models and of alternative government development policies.

11.422 Seminar in Self-help Housing, Squatters, and Social Change

Research and seminars continuing 11.421. Students may work in teams on an in-depth analysis of development systems in a particular urban area or on specific aspects or problems in a context that they know through personal experience. Those so qualified may use both 11.421 and 11.422 for a unified program. A major paper required on the basis of the research material obtained in 11.421.

15.223 International Business Environments

Divided into four sections. Focus of each section on a different region (Europe, Latin America, Japan, North America). Subject areas in each: historical inputs; social-psychological dimensions; political and economic structure; characteristics of labor organizations, financial institutions, and market structure. Relation of such environmental variables to company organization, managerial behavior, corporate policy. Treatment of important social issues confronting the business community. Sections meet

separately for most sessions. Insofar as scheduling permits, students permitted to move among sections following subjects of greatest personal interest on an inter-regional basis.

15.317 Comparative Studies of Organizations

Seminar examining studies of management of organizations in various parts of the world. Determination of which ways of managing are most appropriate in different countries and whether any general principles of management are valid internationally. Beginning with basic theoretical and empirical work in organization studies, seminar continues with an examination of findings about organizations outside of the United States, and concludes with an examination of cross cultural aspects of technical assistance. Each student encouraged to become an expert on organizational studies in a particular country. Topics to be covered: motivation of workers and managers, power and control, communications, the generality of participative approaches such as Theory Y or System IV, and organizational development.

PUBLICATIONS

Theses

Completed

Carlos Varela, "A Study on Ferro-Cement: Theories, Properties and Applications", B.Sc. degree, Supervisor: Professor N. Cook.

Albert Fong , "The Air Permeability of a Commercial Concrete Pipe", B.Sc. degree, Supervisor: P. Griffith.

Pedro Cruz, "A Preliminary Simulation Model of Factors Affecting the Nutritional and Health Status of Children in Low Income Families", M.S. degree, Supervisor: Professor R. E. Stickney.

Jerome M. Gruber, "Formulation of a Least-cost Diet Supplement for Pre-school Children of El-Salvador", M.S. degree, Supervisor: R. E. Stickney.

Mario Alfredo Guerrero, "A Systems Analysis of Government Policies for Improving the Nutritional Status of Low-income Families in El-Salvador: Preliminary Considerations", M.S. degree, Supervisor: Professor R. E. Stickney.

Kyriakos H. Sarris, "An Approximate Analytical Model for Estimating the Effectiveness of a Food Supplementation Program for Children in El-Salvador", M.S. degree, Supervisor: R. E. Stickney.

George Gattoni and Praful Patel, "Residential Land Utilization: Case Study Nairobi, Kenya", M.Arch.A.S. degree, Supervisor: Professor H. Caminos.

In Progress

Allan Castaline, "Comparison of Urban Transportation Systems for Developing Countries", M.S. degree, Supervisors: Professors D. Roos and N. Wilson.

Yui Motomura, "Benefits Associated with Urban Transportation Investment in Developing Countries," M.S. degree, Supervisors:

Professors D. Roos and N. Wilson.

Bruce Kutnick, "The Nature of R & D by Industrial Firms in India," Ph.D., degree, Supervisor: Professor J. Bhagwati.

Presented Papers and Reports

R. E. Stickney, P. C. Abbott, and J. G. Chamberlin, "Systems Approach to Nutrition Planning: Preliminary Considerations in Proceedings of the Symposium on Systems Approaches to Developing Countries, (Algeria, May 28-31, 1973), M. A. Cuenod and S. Kahne, editors, International Federation of Automatic Control, 1973, pp. 137-147.

F. Moavenzadeh, Transfer and Adaptation of Technology in the Construction Industry, presented at the AID Symposium on Bilateral Aid Strategies and Programs in Selected Areas of Science and Technology, Cornell University, May 7-8, 1973.

F. Moavenzadeh, Selection of Optimal Investment Strategies for Low Volume Roads, presented at the annual meeting of the Planning, Transport, Research and Computation Company Ltd., University of Sussex, June 1973.

"Interim Urbanization Project Dandora: A Progressive Development Proposal including a Site and Services Model" (Urban Settlement Design Program; Spring 1973, 46 pages).

"Basic Performance Standards for Urbanization in Latin America and East Africa" (Urban Settlement Design Program).

"Identification of Dwelling Systems in Nairobi, Kenya" (Urban Settlement Design Program). Twenty case studies of typical dwellings have been surveyed l analyzed.

David C. Major, Notes on the Program in Technology Adaptation at MIT, Presented at the Batelle Research Conference on Successes and Failures in Technology Transfer, Seattle, Oregon, November 1972.

David C. Major, "Investment Criteria and Mathematical Modelling Techniques for Water Resources Planning in Argentina: the MIT Argentina Project", Proceedings, IFAC/IFORS Conference on Systems Approaches to Developing Countries, Algiers, May 1973.

Raymond A. Ausrotas, Air Transportation in Developing Countries, Flight Transportation Laboratory Technical Memorandum 73-12, July 1973.

Curtis S. Smith and Jan T. Taniguehi, Material Adaptation for Developing Nations: Progress Evaluation, May 1973.

Athar P. Ahmad, Ferro-cement Journal Bearing, May 1973.

Nuri Kayansayan, An Estimate of Steam Condenser Needs for Less Developed Countries, May 1973.

Iqbal Rashid, Concrete Shell Heat Exchanger Protective Coatings, May 1973.

H. Abtahi, A Reinforced Concrete Shell for the Conventional Single-Pass, Single or Multi-Pressure Steam Condensers, August 1973.

Ian D. Terner, "Technology Assessment for Low-Cost Housing in Third World Countries" presented at the International Congress on Technology Assessment, The Hague, Netherlands, May 27-June 2, 1973.

GRANT RELATED ACTIVITIES

Many research groups and individual faculty members at the Institute, in addition to those mentioned in the report, have been involved in programs relating to technology for developing countries. No current listing of all these activities is available. However, from time to time, the Technology Adaptation Program has inventoried both course offerings and research projects at the Institute which relate to the interests of the program. The last inventory was made in July of 1972. Copies have been sent to the Office of Science and Technology at AID.

The following two ongoing projects at the Institute are particularly relevant to the interests of the Technology Adaptation Program:

1. Title: Developmental Studies of the Sahel-Sudano Zone of Africa (To Start September 1, 1973)

   Principal Investigator: Professor William W. Seifert (Civil Engineering)

2. Title: Technical and Economic Factors in Telecommunications for Developing Countries

   Principal Investigators: Professors G. W. Rathjens (Political Science) and J. P. Ruina (Electrical Engineering)

NEXT YEAR'S PLAN OF ACTIVITIES

Almost all of the projects listed in this report will continue for the next calendar year. The proposed expenditures for these programs is listed in the Tables below. In addition to the projects, an Institute-wide seminar series on problems relating to technology and development will be initiated during the academic year 1973-74.

Table I

Distribution of 211 (d) Funds*

Review Period July 1, 1972 to September 1, 1973

(List all grant related activities)	211 (d) Expenditures			
	Period Under Review	Cumulative Total	Projected Next Year	Projected to End of Grant
e.g. Research & Course Development	$211,100	$222,500	$226,500	$883,100
Libraries	100	100	200	1,000
Consultation	200	200	300	1,400
Publication	2,000	2,500	3,000	14,500
TOTAL	$213,400	$225,300	$230,000	$900,000

*These figures are our best estimates

Table II

Expenditure Report

(Actual and Projected)

Under Institutional Grant #AID/csd 3360

Review Period July 1, 1972 to September 1, 1973

	Expenditures to Date		Projected Expenditures Year			Total
	Period under Review (14 months)	Cumulative Total (21 months)	3	4	5+ (15 months)	
Salaries	$165,300	$175,300	$179,000	$160,000	$186,700	$701,000
Travel	31,000	32,200	33,000	28,000	30,000	123,200
Other	17,100	17,800	18,000	18,000	22,000	75,800
TOTAL	$213,400	$225,300	$230,000	$206,000	$238,700	$900,000